HURRICANE SURVEY

INTERIM REPORT

MAINE COASTAL AND TIDAL AREAS

U.S. Army Engineer Division, New England
Corps of Engineers
Waltham, Mass.

5 JUNE 1964

SYLLABUS

The major cause of damage from tidal flooding and wave attack along the coast of Maine is the "northeaster" coastal storm, not the tropical hurricane. The record levels of flooding were experienced in the "northeaster" of 20 November 1945 and in the storm of 29 December 1959. The record levels experienced in these storms are approximately two feet above the stage of an annual high spring tide. The highest stage of tidal flooding in a hurricane was recorded in "Carol" on 31 August 1954 and was less than those in the two record "northeasters". Flooding along the Maine coast in the hurricanes of September 1938 and September 1944, which were severe in southern New England, was at or below the level of an annual spring tide.

The damages from tidal flooding in the past have been small and scattered along the coast. In the December 1959 flood, which caused near record flooding, the damages to shore properties amounted to an estimated $25,000. The damages, other than to boats, in the recent storms of 20 January 1961 and 30 November 1963 were reported to be minor and resulted mainly from the flooding of cellars and damages to seawalls and low-lying sections of

highways. In view of the small amount of damage to shore developments, it has been found impractical to provide protection against tidal flooding along the Maine coast between the Kennebec River and Eastport. It is concluded that it would be desirable for local interests to give serious consideration to the following measures to lessen future tidal-flood losses:

1. The establishment and/or modification and expansion of present emergency mobilization measures for the evacuation of low-lying coastal areas during floods, taking into account such factors as the need for escape or evacuation routes.

2. The adoption of zoning regulations to control future development within the area of tidal flooding.

3. The adoption of building regulations establishing minimum elevations for first floors in new construction, and requiring improved construction methods in areas subject to flooding.

The Division Engineer recommends that no improvements for hurricane protection in the coastal and tidal areas of Maine be undertaken at this time.

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U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54, MASS.

RESS REPLY TO:
ISION ENGINEER

REFER TO FILE NO.

NEDED-R

5 June 1964

SUBJECT: Hurricane Survey Report on Maine Coastal and Tidal Areas

TO: Chief of Engineers
ATTN: ENGCW-PD
Washington, D. C.

AUTHORITY AND INTRODUCTION

1. In view of the severe hurricane damages experienced in the eastern and southern coastal areas of the United States, the 84th Congress on 15 June 1955 adopted Public Law No. 71 which authorized the Corps of Engineers to undertake a study of means to prevent the loss of human lives and damage to property from hurricane tidal flooding in these areas.

The authorizing legislation provides that first consideration be given to areas where severe damages have occurred. Studies have therefore been completed on critical areas along the Massachusetts, Rhode Island, and Connecticut coasts in southern New England. These studies have led to the authorization for construction of 10 projects, three of which have either been completed or are currently under construction. In addition, these past studies have led to recommended proposals for hurricane tidal protection projects at two other locations.

This report, prepared pursuant to the authority of Public Law No. 71, covers the coastal and tidal areas of Maine from the mouth of the Kennebec River to Eastport. It is one of a series of reports on the shore areas of New England for which previous hurricane survey reports have not been prepared. It briefly examines economic development of the area, indicates the extent of the tidal flood problem along the coast and points out certain measures which may be adopted by local interests to reduce future tidal flood damages.

The coastal problems along the Maine shore from the New Hampshire state line to the mouth of the Kennebec River will be considered in a report to be prepared under the authority of Section 206 of the Flood Control Act of 1958 (Public Law 85-500, approved 3 July 1958) and Section 208 of the Flood Control Act of 1960 (Public Law 86-645, approved 14 July 1960). These two acts authorize survey studies for flood control and allied purposes. The first covers the "Short Sands section of York Beach, York County, Maine" and the latter covers "Oguinquit, York, Wells, Kennebunk, Kennebunkport, Biddeford, Saco, Old Orchard, Cape Elizabeth, Portland, and Phippsburg, and adjacent Maine coastal areas. The specifically named localities in these two acts include the entire ocean frontage of Maine from the New Hampshire line to the Kennebec River with the exception of four towns at separated locations.

DESCRIPTION

2. The coastline of Maine extends northeasterly along the Atlantic Ocean from the Piscataqua River at the New Hampshire state line to the St. Croix River at the international boundary between Canada and the United States, a straight line distance of approximately 250 miles. The total tidal shoreline of the state, including all bays, inlets and other indentations, and the major islands, measures over 2500 miles. The area covered by this report includes 62 towns and accounts for approximately 80 percent of the total coastal area of the state. In general, the coastal terrain in the vicinity of the lower Kennebec River is fairly flat, becoming more hilly and rugged toward the northeast. The entire shoreline is irregular and marked by numerous bays, coves, estuaries, and rocky promontories with innumerable offshore islands. The three major navigable rivers in the report area are the Kennebec, Penobscot, and St. Croix.

ECONOMIC DEVELOPMENT

3. GENERAL

Fishing, the construction and repair of boats, manufacturing, and agriculture are important factors in the economic welfare of the cities and towns in Maine east of the Kennebec River.

The accommodation of tourists and summer residents is also important to the area's economy. The region is served by a network of highways and by the Maine Central Railroad with a line connecting the principal population centers along the coast. Passenger air service is provided to Rockland during the summer season. Seasonal and year-round ferry service is maintained between numerous island communities and the mainland and from Bar Harbor to Yarmouth, Nova Scotia.

4. POPULATION

The year-round population of the 62 towns in the coastal area north and east of the Kennebec River has remained fairly stable over the last decade, ranging from 75,460 in 1950 to 74,712 in 1960, a decrease of about one percent. During this period, the population of the state as a whole increased by 6.1 percent, to a total of 969,265 in 1960. The population of the sea-coast region increases markedly during the summer as a result of the influx of summer residents and vacationists.

5. INDUSTRY

Industrial activity in the report area centers around the processing of fish and shellfish at some 70 plants at scattered locations along the coast, and the operation of over 40 yards engaged in the building and repair of fishing and recreational boats. In addition, there are a number of manufacturing plants located in the area which produce a diversified line of products including textiles, wooden goods, and electrical equipment.

6. NAVIGATION AND COMMERCE

There are 45 authorized Federal navigation projects in the study area along the Maine coast between the Kennebec River and Eastport. Forty-two have been completed. These 45 projects include the provision of channels, anchorages, and turning basins with depths ranging from 3 to 27 feet at mean low water, and the construction of breakwaters and jetties at eight locations. Fifteen of the projects are now utilized for the benefit of commercial navigation. The total waterborne commerce at these projects in 1962, including both receipts and shipments, amounted to over 3.1 million

tons. Over 83 percent of this total was handled at two of the projects, the Penobscot River and Searsport Harbor; and about 15 percent of the total at three projects, the Kennebec River, Rockland Harbor and Lubec channel. About 2,175,000 tons, or 70 percent, of the total 1962 commerce, consisted of the receipts of petroleum and petroleum products.

7. RECREATION

The provision of services associated with outdoor recreational activity is important to the economic welfare of the coastal communities of Maine. There are summer hotels, tourist inns, vacation camps, and other accommodations in virtually all of the shore towns. Camping grounds are available at the Acadia National Park on Mount Desert, at Camden Hills State Park in Camden and Lincolnville, and at Lamoine State Park in Lamoine. Extensive use of the many fine harbors along the coast is made by recreational craft duringthe summer season.

TIDAL FLOODING

8. Information on experienced tide heights along the Maine coast is available from the records of U.S. Coast and Geodetic Survey gages at Portland for the past 50 years, at Bar Harbor for the past 13 years, and at Eastport for the past 35 years. These records, supplemented by the records of storm experiences at other locations, indicate that the highest stages of tidal flooding along the Maine coast, from the Kennebec River to Eastport, have been caused by storms commonly referred to as "northeasters", and not by hurricanes. The occurrence of coastal storms in New England, including both "northeasters" and hurricanes, have been recorded since the time of the first white settlers. Nearly all of the more severe "northeasters" have occurred during the months from November through April, whereas the more important tropical hurricane experiences have occurred in the months of August and September.

The mean range of tide along the coast, in the report area of Maine, varies from 8.4 feet at the mouth of the Kennebec River, from 4.1 feet below to 4.3 feet above mean sea level, to 18.2 feet at Eastport, from 9.2 feet below to 9.0 feet above mean sea level. An annual high spring tide will reach an elevation ranging from approximately 6.6 feet msl at the Kennebec River to 12.5 feet at Eastport, or stages that are 2.3 and 3.5 feet above mean high water, respectively.

The record level of tidal flooding was experienced in the "northeaster" of 20 November 1945 with a stage that ranged from about 8.5 feet msl at the mouth of the Kennebec River to 13.9 feet msl at Eastport. This record stage is approximately two feet above the level of an annual spring tide. Nearly the same level of flooding - about one-tenth foot lower - was experienced in the storm of 29 December 1959. In the storm of 30 November 1944, tidal flooding to the record level was experienced in the vicinity of the Kennebec River, at the west end of the report area, but at Eastport, the stage during this storm was nearly one foot below the record. The highest recorded tide in a hurricane was occasioned by "Carol" on 31 August 1954 when a stage ranging from about 7.7 feet to 10.0 feet msl was experienced along the Maine coast east of the Kennebec River. The tidal flood levels in Maine during the hurricanes of September 1938 and September 1944, which were particularly severe in southern New England, were on both occasions at or below the level of an annual spring tide.

The observed and estimated tide heights at four locations along the coast between Portland and Eastport, Maine, in five "northeasters" and three hurricanes, are tabulated on the following page.

A survey of "northeasters" affecting the northern New England coast is contained in a report, Memorandum HUR 8-5, subject: "Criteria for a Standard Project Northeaster for New England North of Cape Cod", dated May 28, 1963, prepared by the Hydrometeorological Section, Hydrologic Services Division, U.S. Weather Bureau. The survey includes a description of the characteristics and a short history of "northeasters", and a frequency analysis of the tides and storm surges in such storms.

TABLE I

TIDAL FLOOD ELEVATIONS

PORTLAND TO EASTPORT, MAINE

Storm	Tidal Elevations (feet msl) Portland	Kennebec R.	Bar Harbor	Eastport
21 Sept 1938(1)	6.8	6.6*	-	11.7
14 Sept 1944	5.0	4.8*	-	8.8
30 Nov 1944	8.7(2)	8.5*(2)	9.2*	13.0
20 Nov 1945	8.7(2)	8.5*(2)	9.7*(2)	13.9(2)
31 Aug 1954(1)	7.9	7.7*	6.4	10.0
29 Dec 1959	8.5	8.3*	9.6	13.8
20 Jan 1961	8.3	7.4*	8.6	12.5
30 Nov 1963	7.9	6.6*	8.6	13.3
Annual Spring Tide	6.7	6.6	7.4	12.5
Mean High Tide	4.5	4.3	5.1	9.0

(1) Hurricane
(2) Record High
* Estimated Stage

TIDAL FLOOD DAMAGES

9. The damages from tidal flooding along the coast of Maine, between the Kennebec River and Eastport, have been moderate in the past. In Hurricane "Carol" on 31 August 1954, the record hurricane tide level, the estimated damages, excluding wind damage, were minor in amount. In the storm of 29 December 1959, which caused a near record stage of flooding in the report area, the damages to shore properties, excluding damage to boats, fish traps, and similar items, amounted to an estimated $25,000. The reported damages to shore properties in the two recent storms of 20 January 1961 and 30 November 1963, were also minor and resulted mainly from the flooding of cellars and damages to seawalls and low-lying sections of highway.

TIDAL-FLOOD PROTECTION MEASURES

10. A relatively small amount of damage has been sustained by shorefront property along the eastern Maine coast by reason of tidal flooding. Moreover, its scattered locations limit the need and opportunities for protection. The rocky indented shoreline, with its fringe of offshore islands, offers much material protection to shore developments. With a population expansion and increased recreational pressure, the provision of protective measures along the coast may become desirable.

Protective measures that may be considered for reducing future tidal-flood damages fall into the following general classes.

a. Positive protective structures. - These measures include structures such as barriers, with gated or ungated openings, which would completely or partially close off a waterway to the entry of storm tides; dikes and seawalls which would hold back the high water; and breakwaters which would effect a reduction in the height of the waves.

b. Flood proofing, strengthening, or relocating existing buildings. - Following Hurricane "Carol" in 1954, a number of homes and other buildings in southern New England were relocated or raised to place their first floor level above the height of expected future hurricane tides. To mitigate future tidal flood losses along the eastern Maine coast, consideration may be given as necessary to the permanent relocation of goods and equipment to floor levels above the highest experienced tidal flood level, relocation out of the flood plain, flood proofing, and/or more substantial construction to resist the obstructive forces of high water and waves.

c. Restrictive zoning regulations and building codes. - The adoption of flood plain zoning regulations and modified building codes requiring sturdier construction can be effective steps in controlling the future development of flood-prone areas to make them less vulnerable to the hazards of tidal flooding.

d. Hurricane warning and emergency flood mobilization measures. - These measures, coupled with plans for evacuation, including the improvement of escape routes, are feasible measures to lessen property damages in areas subject to damage in future storms. Coastal towns should adopt programs for the evacuation of residents who live in flood-prone areas and for their accommodation during the emergency period. These evacuation programs, together with the hurricane warning services now provided by the U.S. Weather Bureau, are essential supplements to other protection plans for the area. An example of mobilization measures that can be taken is contained in a report entitled "A Model Hurricane Plan for a Coast Community." This report was prepared in 1959 by the Weather Bureau, U.S. Department of Commerce, in collaboration with the Corps of Engineers.

DISCUSSION AND CONCLUSIONS

11. Northeast storms, rather than hurricanes, constitute the major cause of tidal flooding and wave damage along the Maine coast between the Kennebec River and Eastport. The record level of tidal flooding, experienced in the storm of November 1945 is approximately two feet above the level of an annual spring tide. Due to the extremely rocky and rugged character of the greater part of the Maine coast east of the Kennebec River and to the sparesely developed character of the area, flooding to the record level would cause damages estimated at less than $100,000 to shore properties. This damage would be at scattered locations along the approximate 2,000 miles of coast in this area. The greatest damage in severe storms along this portion of the Maine coast is to boats, docks, and fishing equipment.

Owning to the relatively small amount and scattered nature of the damage that would be sustained along the shore in a recurrence of the record flood level, it has been concluded that under present economic conditions and current requirements for Federal participation, the provision of positive tidal-flood protection measures, to and above the record level, are not warranted at this time. It has also been concluded that it would be desirable for local interests, both public and private, to give serious consideration to the following measures to lessen future damages from tidal flooding.

a. The establishment and/or modification and expansion of present emergency mobilization measures for the evacuation of low-lying coastal areas during floods, taking into account such factors as the need for escape or evacuation routes.

b. The adoption of zoning regulations to control development within the tidal flood plain.

c. The adoption of building regulations establishing minimum elevations for first floors in new construction, and requiring improved construction methods in areas subject to flooding.

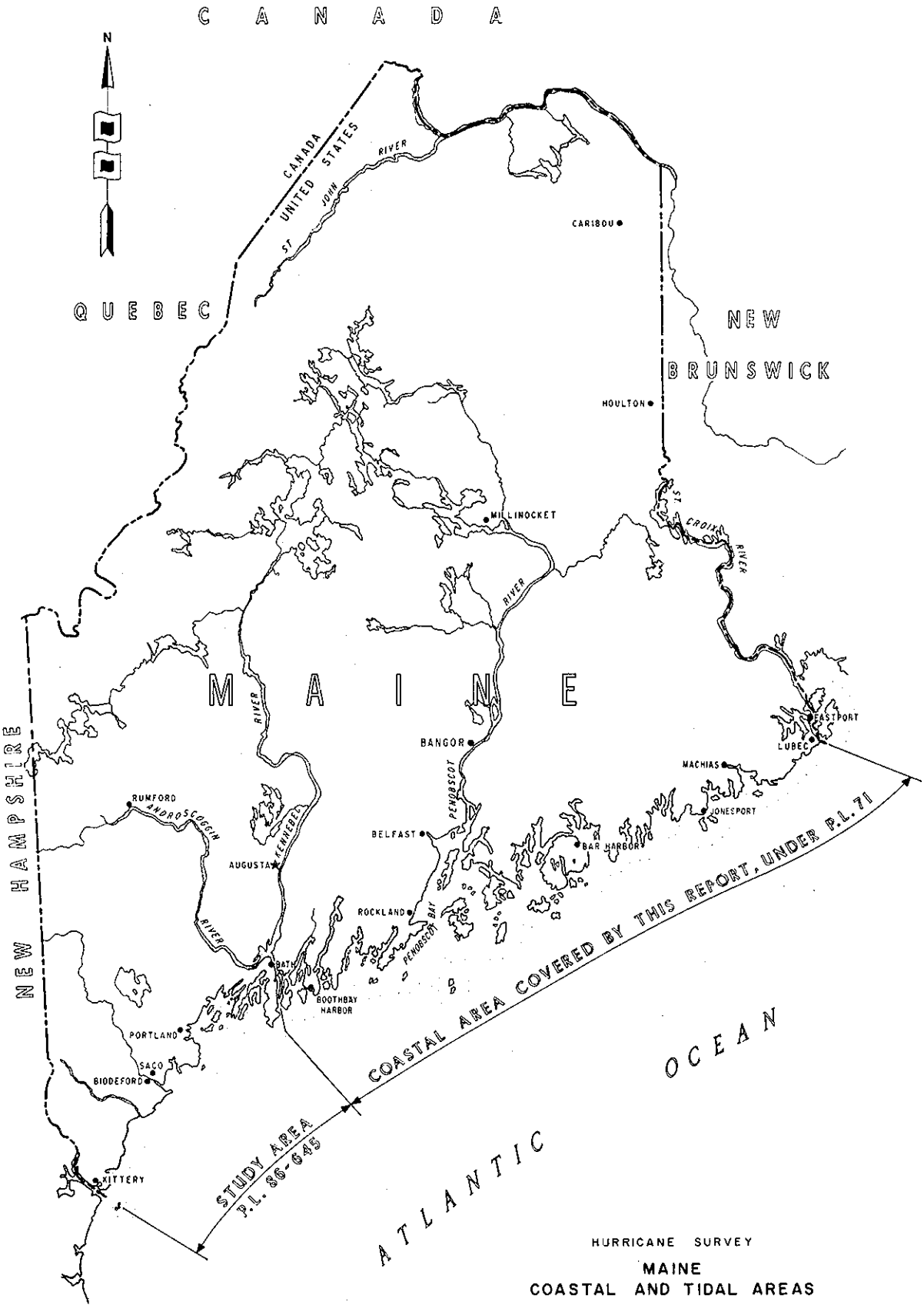
RECOMMENDATION

12. It is recommended that no improvements for hurricane protection in the coastal and tidal areas of Maine, east of the Kennebec River, be undertaken by the United States at this time.

It is further recommended that this report be printed to serve as a guide to public and private interests in their long-range planning for the full development of the lands, waters and other natural resources of the Maine coastal area.

It is also recommended that this report be accepted as complying in full with the directive contained in Public Law No. 71 insofar as it pertains to Maine.

P. C. HYZER
Brigadier General, USA
Division Engineer



HURRICANE SURVEY

MAINE
COASTAL AND TIDAL AREAS

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. JUNE 1964
SCALE AS SHOWN

PLATE I